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Literature Review: The Role of Contextual Teaching and Learning in Developing Lab Instructions to Enhance Students' Academic and Communication Competencies

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Abstract
This article aims to examine the development of practical instructions based on Contextual Teaching and Learning (CTL) as an effort to improve students' learning outcomes and communication skills through a literature review approach. The writing of this article was motivated by the need for a learning model that not only focuses on cognitive aspects, but also strengthens communication skills and understanding concepts through learning experiences that are relevant to life contexts. The method used is a literature review by examining various appropriate research results, including articles in national journals indexed by SINTA (S1–S5) which discuss the application of CTL in practicum activities. Data were analyzed using a descriptive-comparative approach to reveal patterns, effectiveness, and supporting factors and challenges in implementing CTL in practicum-based learning. The results of the study show that CTL-based practicum guides consistently provide a positive impact on improving learning outcomes through active student involvement and direct learning experiences, as well as helping develop scientific communication skills. It is hoped that this article will become a reference source for educators and researchers in designing learning strategies that are contextual, collaborative, and in line with the competency needs of the 21st century.

***Keywords**: CTL, practicum, cognitive, communication, literature review.*

Abstrak
Artikel ini bertujuan mengkaji pengembangan petunjuk praktikum berbasis Contextual Teaching and Learning (CTL) sebagai upaya meningkatkan hasil belajar dan kemampuan komunikasi peserta didik melalui pendekatan tinjauan pustaka. Penulisan artikel ini dilatarbelakangi oleh kebutuhan akan model pembelajaran yang tidak hanya berfokus pada aspek kognitif, tetapi juga memperkuat keterampilan komunikasi serta pemahaman konsep melalui pengalaman belajar yang relevan dengan konteks kehidupan. Metode yang digunakan berupa kajian literatur dengan menelaah berbagai hasil penelitian yang sesuai, termasuk artikel pada jurnal nasional terindeks SINTA (S1–S5) yang membahas penerapan CTL dalam kegiatan praktikum. Data dianalisis dengan pendekatan deskriptif-komparatif untuk mengungkap pola, efektivitas, serta faktor pendukung maupun tantangan dalam pelaksanaan CTL pada pembelajaran berbasis praktikum. Hasil penelaahan menunjukkan bahwa panduan praktikum berbasis CTL secara konsisten memberikan dampak positif terhadap peningkatan hasil belajar melalui keterlibatan aktif siswa dan pengalaman belajar langsung, serta membantu mengembangkan kemampuan komunikasi ilmiah. Artikel ini diharapkan menjadi sumber rujukan bagi pendidik dan peneliti dalam merancang strategi pembelajaran yang kontekstual, kolaboratif, dan sejalan dengan kebutuhan kompetensi abad ke-21.

***Kata Kunci**: CTL*, praktikum, Kognitif, komunikasi, *literature review*

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INTRODUCTION

In general, science education aims to foster scientific thinking skills while also developing students' process skills. However, in practice, many students still face difficulties in connecting scientific concepts with real-life phenomena. This situation occurs because classroom learning often emphasizes mastery of theory without providing learning experiences that are close to real-world contexts. The Contextual Teaching and Learning (CTL) approach is offered as an alternative to bridge the gap between theory and its application by emphasizing the relationship between subject matter and students' life experiences (Zimmerman & Smit, 2014).

Through this approach, learning becomes more meaningful because students actively build knowledge through direct and authentic experiences. One effective form of CTL implementation can be seen in the development of science lab instructions. CTL-based lab guides not only present experimental procedures but also provide opportunities for students to investigate, discover, and connect lab results with real-world phenomena around them. Research by Nurhadi et al. (2019) shows that the application of CTL in lab activities can increase student engagement and deepen conceptual understanding through empirical experiences. In addition, this approach also enhances learning motivation and curiosity because students feel that lab activities are connected to their lives. CTL also contributes to the development of students' communication skills. Through collaborative activities such as group work, discussions, and presenting results, students practice expressing ideas, giving feedback, and respecting others' opinions constructively. Rusman (2020) emphasizes that CTL plays a role in strengthening soft skills, including teamwork and interpersonal communication, which are part of essential 21st-century competencies. Thus, the implementation of CTL in practical work is not only focused on academic achievements but also supports the development of students' social and communication abilities.

However, in reality, practicum guides that are procedural and only oriented towards achieving the final results without encouraging students' thinking are still found. Such guides make students merely follow steps without understanding the essence of the activity. Findings by Sari & Widodo (2021) indicate that most practicum guides have not been able to stimulate students' reflective and critical thinking skills. Therefore, it is necessary to develop CTL-based practicum guides that require students' activeness in building concepts through real contexts. Overall, the development of CTL-based practicum instructions can be seen as an appropriate strategy to enhance both the academic and communication abilities of students. This approach not only provides more meaningful and relevant learning, but also encourages the development of students' character to be collaborative, creative, and reflective. With research evidence showing the effectiveness of CTL in science learning (Zimmerman & Smit, 2014), this study is expected to contribute both theoretically and practically to the improvement of the quality of science education in schools.

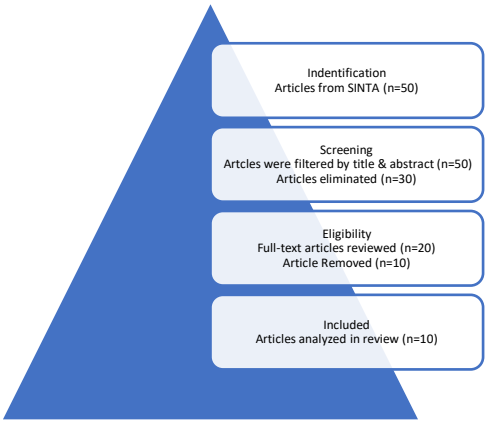
METHODS

This article was prepared using the literature review method, which is a research approach that focuses on activities of data collection, analysis, and synthesis from various relevant scientific sources. This method aims to gain a comprehensive understanding of the application of the Contextual Teaching and Learning (CTL) model in developing laboratory manuals as a strategy to improve students' learning outcomes and communication skills. The literature review process is carried out through several structured stages. The initial stage involves the identification and selection of sources, where the author searches for scientific articles from nationally accredited Sinta journals as well as international publications published between 2015 and 2025. The reference

search is conducted through several databases, such as Google Scholar, DOAJ, and Garuda, using keywords like Contextual Teaching and Learning, science practicum, learning outcomes, and students' communication skills.

The next stage is the analysis of literature content. At this stage, the selected articles are examined to identify patterns of similarity, variation, and each article's contribution to the development of context-based learning. The analysis is carried out using a content analysis approach, which allows researchers to categorize findings based on themes, such as the effectiveness of CTL implementation, its application in practical activities, and its impact on students' academic abilities and communication skills (Miles, Huberman, & Saldaña, 2018). The final stage is the synthesis process, which involves combining various findings from literature sources to produce a comprehensive understanding of the effectiveness of CTL. Synthesis is conducted by comparing the results of previous studies and interpreting their implications for the implementation of contextual learning. This synthesis serves as the basis for drafting conclusions and recommendations related to the development of CTL-based laboratory manuals in the future (Snyder, 2019)

Through this approach, this article is expected to provide a critical analysis of previous research as well as offer theoretical and practical contributions to the enhancement of context-based learning in schools. Articles published in journals accredited by Sinta 1 to Sinta 5 have generally undergone a rigorous review and selection process, thus possessing considerable academic credibility. During the review stage, reviewers typically assess the clarity of the writing framework, the appropriateness of the methods used, and the relevance of the findings to the latest scientific developments. Furthermore, publications from the past ten years are considered more relevant as they reflect the most recent advancements in theory, approaches, and educational technology. Therefore, the use of current references needs to be considered so that the theoretical foundation used remains in line with the current research developments. Thus, selecting sources from Sinta-indexed journals (S1–S5) and recent publications becomes an important aspect in determining the quality of references used in the literature review. Articles that meet these criteria have the potential to provide findings that are credible, relevant, and useful for further research.



The article selection process in this study followed the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The literature search was conducted through the SINTA database for publications from 2015 to 2025 and was limited to journal articles. At the identification stage, a total of 50 articles matched the search keywords. Next, a screening process was conducted based on the suitability of the titles and abstracts, resulting in the elimination of 30 articles that were not relevant to the study focus and did not meet the initial research criteria.

The remaining 20 articles were then thoroughly reviewed through full-text reading to assess methodological feasibility and the substance of the discussion. From this stage, 10 articles were excluded for not meeting the established inclusion criteria. Thus, a total of 10 journal articles were deemed eligible and used as the main data sources in the analysis and discussion process of this review.

RESULTS AND DISCUSSION

In general, various perspectives on Contextual Teaching and Learning (CTL) state that this approach serves as a means for educators to connect the material being taught with the real conditions experienced by students (Hasudungan, 2022). Through the implementation of CTL, students are guided to relate the concepts learned in class to their practical application in daily life, both within the family and the community. Environmental issues become one of the important aspects of learning because they are directly related to students' realities and routines. Therefore, strengthening environmental material in the learning process needs to be supported through the application of relevant learning models (Bawotong et al., 2024).

Table 1.Article on the relationship between Contextual Teaching and Learning (CTL), lab instructions, learning outcomes, and communication skills.

Code	Research Title	Research Results
P1	Development of Physics Learning Devices Based on the Contextual Teaching and Learning (CTL) Approach to Motivate and Improve the Physics Learning Outcomes of 8th Grade Students at SMP Negeri 1 Balocci Pangkep (Makassar et al., 2015)	The research results show that the developed learning devices, which include lesson plans, teaching materials, student worksheets, and assessment instruments, have been validated and obtained very high reliability scores, thus meeting the eligibility criteria for use in learning activities. These devices were then implemented in the learning process in class VIII-D with the topic of object motion. After the implementation of the devices, students' learning motivation was measured using a questionnaire instrument. The findings show that most students fall into the high to very high motivation category. In addition, the evaluation of learning outcomes, which covers three domains, also shows significant improvement; the cognitive domain is in the high category, while the psychomotor and affective domains fall into the very high category.
P2	Development of Biology Learning Modules on Ecosystem Material Based on the Contextual Teaching and Learning (CTL) Approach (Kalsum et al., n.d.)	In addition, the results of the effectiveness testing showed that the module falls into the effective category with an average score of 80.62. Out of all the students, 28 students or about 87.5% successfully achieved the learning mastery, while 4 students or 12.5%

		did not meet the established mastery standards. These results indicate that, although there are still some parts that require improvement, the developed module can be considered feasible for implementation in learning activities.
P3	The Implementation of the CTL (Contextual Teaching and Learning) Model Assisted by Visual Media on Student Learning Outcomes in Plant Tissue Material (Purba et al., 2019)	The research results show a significant increase in student learning outcomes after the implementation of the learning model. Before the treatment was applied, the average pre-test score was recorded at 43.9. After using the Contextual Teaching and Learning (CTL) model, the average post-test score increased to 77.00. The N-Gain calculation showed a percentage increase of 58.53, which falls into the "very efficient" category. Thus, the use of the CTL model combined with visual media on network material for 11th-grade science students (XI IPA II) is considered effective in improving learning outcomes.
P4	Development of Science Practicum Guidelines Based on Process Skills to Improve Critical Thinking Skills of Elementary School Students (Proses et al., 2018)	The research results measuring the effectiveness of critical thinking skills showed that: (1) the indicator for the ability to provide simple explanations obtained an N-Gain score of 0.40, categorized as moderate, (2) the indicator for the completeness of explanations reached an N-Gain score of 0.37, also in the moderate category, and (3) the indicator for the ability to provide advanced explanations obtained an N-Gain score of 0.28, which falls into the low category. Based on these achievements, it can be concluded that the implementation of science practical activities designed with a critical thinking skills approach can make a positive contribution to improving elementary school students' critical thinking abilities.
P5	Development of Student Worksheets Based on CTL (Contextual Teaching and Learning) as Teaching Material for 12th Grade High School/Madrasah Aliyah Students on the Subconcept of In Vitro Culture (J. of Biology, 2017)	The development of student worksheets based on the CTL approach on in vitro culture material was carried out based on a preliminary study focusing on observing the growth of duckweed plants on various types of alternative culture media. The results of this initial observation were then used as the basis for preparing the content of the worksheets. In addition, the development of this teaching aid also integrates seven main components in the CTL approach, namely constructivism, inquiry, questioning, learning community, modelling, reflection, and authentic assessment, with the aim of increasing student activity and involvement

		during the learning process. Data collection in this study used evaluation questionnaires to assess the feasibility of the worksheets. The assessment instrument was developed on a scale of 1 to 5 with eight assessment indicators. Validation was carried out by two lecturers from the Biology Education Study Program at Untirta and three high school Biology teachers. Based on the assessment results, the CTL-based student worksheet on in vitro culture material for 12th-grade high school/MA received an average score of 4.3 on the Likert scale and was declared to be in the “very feasible” category for use in learning.
P6	The use of the Contextual Teaching and Learning model to improve student learning outcomes at MIN 2 Sarolangun (Puryanto, 2022)	The research results showed an increase in students' learning achievement after the implementation of the action. In the initial stage, the students' average score was 67 and fell into the poor category. After the implementation of cycle I, the average score increased to 69, reaching a sufficient category. The improvement continued in cycle II with an average of 73, which falls into the good category, and increased again in cycle III with an average score of 75, also in the good category. Based on these findings, it can be concluded that the implementation of the Contextual Teaching and Learning (CTL) model has a positive and effective effect on improving the science learning outcomes of fourth-grade students at MIN 2 Sarolangun.
P7	Development of CTL-Based Physics Modules on Static and Dynamic Fluids to Improve Physics Achievement of 11th Grade High School Science Students (Inquiry, 2016)	The CTL-based physics module for high school is considered feasible to use in the learning process based on validation results from several parties. Two experts gave an average score of 3.92 in the very good category, while two high school teachers gave an average score of 3.95 in the same category. In addition, assessments from two peers showed an average of 3.96, which also falls into the very good category. Student responses in the limited trial also showed a very good category, so the module is considered to meet feasibility aspects from the users' perspective. Based on effectiveness tests, the CTL-based physics module has been proven to have a positive impact on improving learning outcomes of 11th-grade science students. The average N-Gain score in the group using the CTL module was higher compared to the group

		using the student worksheets. The data were obtained through pretest and posttest results in the experimental and control classes. Analysis using the independent samples t-test through SPSS 19 software showed a significance value of 0.008. Since this value is below 0.050, H0 is rejected. Thus, there is a significant difference between the two groups, indicating that the CTL-based module can be considered effective in improving students' physics learning achievement.
P8	The Implementation of the Contextual Teaching and Learning Model in Efforts to Improve Student Activity and Achievement (Wirati, 2023)	Data analysis shows an increase in both student activity and learning achievement after the implementation of the learning approach. This improvement occurs because the contextual learning model allows students to build understanding independently, connect prior knowledge with new experiences, and form concepts through relevant and meaningful learning activities. Based on these findings, it can be concluded that the use of the Contextual Teaching and Learning model has a positive and effective impact on increasing student engagement and learning outcomes in the Front Office subject.
P9	Implementation of a Web-Based Contextual Teaching and Learning (CTL) Approach in Chemistry Practicum at Madrasah Aliyah Negeri 2 Kudus (Kudus, 2016)	Based on research findings, the implementation of a web-based CTL approach has been proven to affect students' learning outcomes on reaction rate material in grade XI IPA at MAN 2 Kudus, with a contribution level of 42.11%.
P10	Development of CTL-Based e-LKPD to Improve Science Process Skills in Temperature and Heat Material (Sa et al., 2022)	The CTL-based electronic worksheets that were developed have been tested on 18 eleventh-grade students at SMAN 1 Anyer. Based on the validation process, the product received an average score of 86.03% from subject matter experts and 86.75% from media experts, both of which fall into the very effective category. On the other hand, students' responses showed an average score of 85.8%, in the very good category. The effectiveness of using these worksheets was analyzed through scientific process skills tests and paired sample tests. The results showed an average n-gain score of 0.57, which falls into the medium category, and there was a significant difference between pre-test and post-test scores. Thus, the CTL-based electronic worksheets are deemed eligible and effective in improving

	scientific process skills in the material of temperature and heat.

Contextual Teaching and Learning (CTL) is a learning approach that emphasizes the connection between the material being studied and the real-life context of students. Through this approach, the learning process is not only oriented towards mastering concepts theoretically but also towards students' ability to relate knowledge to everyday experiences, making learning more meaningful. CTL views learning as an active process that involves students in constructing understanding through interaction with the environment, social situations, and real problems relevant to their lives.

In practice, CTL does not stand as a single method, but rather as a learning system composed of several main components that are interconnected and mutually supportive. Each component has a strategic role in creating learning that is contextual, participatory, and oriented towards the holistic development of students' competencies. Therefore, understanding the components of CTL becomes important so that teachers are able to design and implement learning systematically, consistently, and in accordance with the characteristics of the students.

Based on this framework, the following discussion will elaborate in detail on each component in the Contextual Teaching and Learning approach, including constructivism, inquiry, questioning, learning communities, modeling, reflection, and authentic assessment, as the main foundation for implementing contextual learning in the classroom.

1. Constructivism

   This approach emphasizes that students should develop their own knowledge through active participation in the learning process. Learning activities are no longer focused on the teacher, but on the students. The teacher acts as a companion or facilitator in the learning process, while students are expected to be more active. To facilitate students, teachers must do the following: (a) help students develop relevant and meaningful knowledge; (b) provide them with opportunities to discover and apply their own knowledge; and (c) encourage students to use their own learning strategies.

2. Inquiry

   Discovery, also known as inquiry, is a learning process that focuses on the search for and acquisition of knowledge through structured or systematic methods. This process transforms the results of observations into understanding so that students can use their critical thinking skills. According to Lukmanul Hakim, a teacher must create a learning environment that gives students the opportunity to work in various ways, such as identifying problems, answering questions, conducting research or investigations, and discussing methods, hypotheses, and explanations that align with their everyday life experiences.

3. Questioning

   Asking questions is an effort to enhance students' desire to learn through interactive conversations in the form of question-and-answer sessions among members of the learning community. By utilizing this activity, the learning process becomes more engaging and is able to produce clear and concise understanding. Through question-and-answer sessions, students are instructed not to accept any opinions, ideas, or theories in a way that is easily understood. This increases their curiosity and desire to learn more about various theories, which encourages them to continue learning.

4. Learning Communities

   The idea of a learning community, or a learning society, focuses on learning through collaboration with others. In the context of CTL, teachers always facilitate learning activities by forming groups of very different people. More capable

students help less experienced students and those who have understood the material provide clarification to those who haven't, and so on. In practice, a learning community means forming various types of groups or teams, whether small teams or large teams, bringing in resource persons into the classroom, collaborating with parallel classes, collaborating with upper-level classes, as well as establishing cooperation with the community.

5. Modeling

   Modeling basically discusses what is being thought, demonstrating how teachers encourage students to learn and do whatever the teacher wants. In contextual education, teachers do not use just one model. Models can be used to inspire students and draw attention from other sources. In sports, such as when throwing and kicking a ball, in activities like memorizing words in a foreign language, or when a teacher shows how to perform a task, the teacher acts as a role model providing examples that can be observed and understood. Every action taken by the teacher becomes a reference for students. When the teacher demonstrates an action, students will feel confident that they too are capable of doing it.

6. Reflection

   Reflection is the process of reviewing, analyzing, clarifying, and being able to conclude what has been learned. In class, reflection is usually carried out at the end of the lesson, when the teacher gives students special time to reflect. Reflection can be done in various forms, such as students' statements about what they have learned, notes or journals written in the student's own notebook, discussions about today's learning activities, or other forms of student learning outcomes.

7. Authentic Assessment

   Authentic assessment is the activity of collecting various data to illustrate students' learning progress. This information can include written texts, projects or activity reports, students' learning outcomes, or presentations, all of which are recorded in the students' portfolio.

Based on the synthesis of ten analyzed articles, it can be identified that the implementation of Contextual Teaching and Learning (CTL) in science learning, particularly through the development of learning tools and practicum guides, shows a relatively consistent trend of findings. In general, all studies reported an improvement in student learning outcomes after the implementation of CTL, in cognitive, affective, and psychomotor aspects. However, the level of improvement achieved and the focus of the developed competencies vary across studies.

From a comparative findings perspective, research oriented towards the development of learning tools (P1, P2, P5, P7, and P10) tends to emphasize the feasibility of the product and the effectiveness of initial implementation. Products such as modules, LKPD, e-LKPD, and CTL-based practicum guides consistently receive categories ranging from “feasible” to “very feasible” based on expert validation results. These findings indicate that CTL principles such as constructivism, inquiry, and contextual relevance can be systematically integrated into learning material design. In contrast, research focused on the implementation of CTL in the learning process (P3, P6, P8, and P9) highlights empirical evidence of learning outcomes improvement through pretest–posttest score comparisons and N-Gain values, confirming CTL's effectiveness in helping students build a deeper conceptual understanding.

From a pattern analysis perspective, there is a tendency that CTL is most effective when combined with practical activities, visual media, or digital platforms. This pattern is evident in studies showing significant increases in student engagement, learning motivation, and group discussion activities. Context-based learning encourages students to connect scientific concepts with real-life experiences, making the learning process

more meaningful rather than merely procedural. However, another emerging pattern is that the development of higher-order thinking skills, such as critical thinking and science process skills, has not been fully optimal. Some studies (e.g., P4 and P10) report improvements that are still in the moderate to low range for certain indicators, indicating the need to strengthen the design of inquiry and reflection activities in practical guides.

Furthermore, the pattern of findings also indicates that the aspect of scientific communication has not been the main focus in most studies. Although CTL implicitly involves collaborative activities, discussions, and result presentations, the measurement of students' communication skills is often still secondary or not specifically assessed with standardized instruments. In fact, communication competence is one of the key 21st-century skills that should develop alongside an increased conceptual understanding.

Based on these comparisons and patterns, several research gaps can be identified. First, most studies focus more on improving cognitive learning outcomes and product feasibility, while research specifically examining the role of CTL-based lab manuals in developing students' scientific communication skills is still limited. Second, there are few studies that explicitly integrate CTL with indicators of written and oral communication in the context of science labs. Third, existing research is generally short-term and focuses on limited trials, so further studies are needed to examine the long-term impact of implementing CTL-based labs and in more diverse learning contexts.

Thus, this synthesis confirms that although CTL has been proven effective in enhancing learning outcomes and the quality of education, there is still room for development in the design of laboratory guides that are not only oriented toward cognitive achievement but also systematically train students' communication skills and scientific reflection. Therefore, the development of CTL-based laboratory guides that explicitly integrate real-world contexts, collaborative activities, and authentic assessment of scientific communication becomes an important contribution that can enrich the body of research and science teaching practices.

CONCLUSION

Based on a literature review of ten research articles discussing the implementation of Contextual Teaching and Learning (CTL) in science education, particularly through the development of learning tools and laboratory guides, it can be concluded that CTL is an effective learning approach for improving the quality of both the learning process and students' learning outcomes. Consistent implementation of CTL has been proven to enhance conceptual understanding, cognitive learning outcomes, motivation, active student engagement, and support the development of thinking skills and scientific process skills. By linking material to real-life contexts, CTL makes learning more meaningful, relevant, and oriented towards authentic learning experiences.

In addition to impacting academic achievement, CTL also has strong potential to develop students' scientific communication skills through collaborative activities, group discussions, laboratory report presentations, and learning reflections. However, the synthesis results show that the development of communication skills has not been the main focus in most studies, thus still requiring reinforcement through the design of laboratory guides and more structured assessment instruments. Therefore, CTL not only serves as a contextual learning strategy but also as a pedagogical framework that supports the holistic development of 21st-century competencies.

Theoretical Implication

Theoretically, the findings of this study reinforce the foundation of CTL (Contextual Teaching and Learning) as a learning approach rooted in constructivist theory, meaningful learning, and experience-based learning. The synthesis results indicate that the integration of CTL components—constructivism, inquiry, questioning, learning

community, modeling, reflection, and authentic assessment—can create a learning ecosystem that encourages students to actively and contextually construct knowledge. This study also emphasizes that CTL is relevant for further development in the context of science practicum learning as a means to bridge theoretical concepts with real-world applications. Thus, this article provides a conceptual contribution in expanding the understanding of the role of CTL not only as a learning model but also as a foundation for developing learning tools oriented toward strengthening academic competence and scientific communication.

Practical Implications

Practically, the results of this study provide important implications for educators, instructional material developers, and education researchers. For teachers, CTL can be used as a reference in designing learning experiences and practical guides that are not only procedural but also encourage students to think critically, engage in discussions, and connect the results of experiments with everyday life phenomena. For instructional material developers, these findings underscore the importance of designing modules, student worksheets (LKPD), e-LKPD, and practical guides based on CTL that explicitly integrate inquiry activities, collaboration, reflection, as well as authentic assessment, including the assessment of students' communication skills.

Meanwhile, for future researchers, this study opens up opportunities for further research focused on the development and testing of CTL-based laboratory guides that specifically target the improvement of students' scientific communication skills, both oral and written, as well as examining their effectiveness in the long term and across various educational levels. Thus, the implementation of CTL is expected to make a tangible contribution to enhancing the quality of science learning that is contextual, collaborative, and aligned with the demands of 21st-century education.

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